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Land Clearing and Wood Utilization By Distillation*



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OF THE
HERCULES POWDER CO.

*This paper was delivered at the Agricultural Extension Directors' Convention at Gulfport, Miss., December 18, 1919. It contains additional tables and cost analyses not available at that time.

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The Hercules Experimental Distillation Plant, near Gulfport, Miss.

INTRODUCTION

EARLY in 1918 our attention was directed by officials of the United States Department of Agriculture, to the problem of developing the cut-over long leaf pine lands of the Southern Coastal Plains. In approaching this problem we realized that it is not a new one. Agricultural authorities have given the subject serious study for many years.

The long leaf pine lands include most of the area of the Coastal Plains extending from Norfolk, Va. to Galveston, Texas, lying between the Piedmont section and the sea coast, excepting only the alluvial tracts of the Mississippi Valley. The soils of this region are predominantly sands or sandy loams, and, with the exception of swamp lands, are, or were, covered almost entirely with long leaf pine timber. Some of them are fertile and adapted to general farming, while some are too poor to be attractive, except for the purpose of reforestation. Over one hundred soil types have been distinguished in the territory embraced. According to seemingly reliable estimates, seventy-six million acres have been cut over, and the saw-mills are adding to this immense total at the rate of ten million acres a year.

Owing to climatic conditions, which are favorable alike to health and to agriculture, and also to the fact that this land is almost the last available large area open to agricultural development in this country, the problem of its ultimate reclamation is one of paramount importance. Agricultural settlers have endeavored to bring the land into cultivation from time to time, but the high cost of clearing has been a serious deterrent to this work. Unfortunately for the would-be settler, the long leaf pine stump does not decay rapidly, as does the hard-wood variety. The tendency of the former to turn rich or fat prolongs its existence almost indefinitely. Moreover, nature provided the long leaf pine tree, over most of its range, with enormous tap roots which increase the difficulty of removing the stump.

Where these lands are of very high agricultural value, as in the citrus sections, the cost of clearing is easily justified. But this is not the case with most of the vast acreage involved, and in any

case it is obvious that the presentation of a method which will materially reduce the expense of clearing these lands, will be a valuable contribution to Southern agriculture.

Officials of the States Relations Service of the United States Department of Agriculture called our attention to the fact that the long leaf pine stump of the South contains resinous matter of commercial value which may be recovered by distillation. They suggested that the Department would be interested in any experiment we might care to make in the utilization of stumps to offset the cost of pine land reclamation.

After seeking advice from the Bureau of Chemistry, we made a preliminary investigation of commercial distillation plants. We soon realized, however, that in order to get accurate information on this subject in its relation to land clearing, we should have to build a plant and operate it. As manufacturers of explosives, we had been interested for years in the subject of land clearing, and this proposal seemed to fit in with our general activities, so we proceeded to carry out the experiment. It has convinced us that the operation of one or more distillation plants in connection with the removal of long leaf pine stumps will materially reduce the cost of the latter operation, and that under the most favorable circumstances it will more than pay for the clearing.

In seeking a location for our experiment, we did not look for ideal conditions. All sections of the long leaf pine regions were visited and in October, 1918, a site was selected in South Mississippi on the Gulf & Ship Island Railroad, seven miles north of Gulfport, Harrison County. There we found what we regarded as fairly average conditions of soil and stumpage. There is no question that there are millions of acres better suited to work of this kind than the spot we chose.

In conducting the experiment, it was our purpose to determine the cost of removing the stumps, the type of plant best suited for small scale distillation, the cost of construction and operation, and the value and saleability of the products recovered.

The succeeding parts of this paper will deal with these various phases of our experiment and the conclusions we have drawn from them.



A section of the cut-over long leaf pine land on which the Hercules Gulfport Experiment was conducted.

PART I.

LAND CLEARING

FOR THE purpose of obtaining accurate cost figures, twenty-five acres of cut-over pine lands were surveyed and subdivided into one-acre and five-acre tracts. The land was rolling in character, one-half being high and dry, and the other half low and wet. The timber had been cut off twice in the past fifteen years, the last time about six years ago. The age of the stumps varied, therefore, from six to fifteen years. A careful record was kept of the material and labor employed, the number of stumps, and their weight per acre.

As the wood must be broken up into pieces that can be easily handled, whether it is designed for the retort or the furnace, blasting was the best means to use, as it removes and splits the stump in one operation. The custom and desirability of shallow plowing in the pine lands made it unnecessary to remove the tap root below a distance of eighteen inches from the surface. This did not leave deep holes in the ground such as those that are made when the whole tap root is pulled out by mechanical means. As the tap root contains no rosin, and is not needed for fuel, leaving it in the ground cuts down the quantity of explosives necessary, and possibly benefits the soil by its decay.

The work was carried out as follows: First, a pit was dug with a spade at the base of the stump from twelve to eighteen inches deep, exposing the tap root. A hole was bored into the root in a downward-slanting direction, but was not allowed to go clear through to the other side. It was found that if the hole were bored clear through, more explosives were required, because the confinement was not as close. A power boring machine was used, equipped with a $1\frac{1}{2}$ H.P. gasoline engine.

When the stumps on an acre were bored, the holes were loaded with dynamite, primed with cap and fuse, and thoroughly tamped with moist earth, the size of the charge varying with the size of the stumps. With a little experience it is possible to gauge the correct quantity of explosives quite accurately. The result of the blast was to cut the tap root entirely off and throw out the base

and the top of the stump, usually split in pieces that could be easily handled. Occasionally, second and third shots were required where the stump did not come out cleanly on the first. Ordinarily it is cheaper to use a repeat shot on a stump than to cut it out by hand. Following the blaster, laborers cut and dug out the clinging lateral roots and piled up the wood so that it could be conveniently loaded for hauling to the plant.

TRACT I

EXPLOSIVES & BLASTING SUPPLIES		
265 lbs. Hercomite @ 25 cents per lb.....	\$66.25	
463 No. 6 Caps @ \$16.15 per 1000.....	7.48	
936 ft. Fuse @ 8 91 per 1000 ft.....	8.34	
		\$82.07
LABOR		
Pitting 9 hrs. @ 28 cents.....	\$ 2.52	
Boring 91 hrs. @ 28 cents.....	25.48	
Blasting 68 hrs. @ 28 cents.....	19.04	
Grubbing 90 hrs. @ 28 cents.....	25.20	
		\$72.24
Total Cost clearing 5 acres.....	154.31	
Cost per Acre.....		\$30.86
NUMBER OF STUMPS—WEIGHT LBS.		
1st acre..... 91	9705 lbs.	
2d acre..... 52	8715 lbs.	
3d acre..... 104	5460 lbs.	
4th acre..... 100	14760 lbs.	
5th acre..... 99	7040 lbs.	
Total..... 446	45680 lbs. — 22.84 tons	
Cost per ton.....		6.76
52 man—hours per acre		
11 man—hours per ton		

TRACT II

EXPLOSIVES AND BLASTING SUPPLIES

266 lbs. Hercomite @ 25 cents.	\$66.50	
530 No. 6 Caps @ \$16.15 per 1000.	8.56	
1060 ft. Fuse @ \$8.90 per 1000 ft.	9.44	
		\$84.50

LABOR

Pitting 5 hrs. @ 28 cents and 5 hrs. @ 34 cents.	3.10	
Boring 28 hrs. @ 28 cents and 35 hrs. @ 34 cents.	19.74	
Gasoline for Boring Machine—5 gallons @ 24.5 cents.	1.23	
Blasting 64.5 hrs. @ 28 cents.	18.06	
Grubbing 93 hrs. @ 28 cents.	26.04	
		\$68.17
Total cost clearing 5 acres.	152.67	
Cost per Acre.		\$30.53

NUMBER OF STUMPS—WEIGHT LBS.

6th acre.	111	9920 lbs.	
7th acre.	123	11250 lbs.	
8th acre.	76	9646 lbs.	
9th acre.	41	7670 lbs.	
10th acre.	75	12925 lbs.	
Total.	426	51411 lbs. — 25.71 tons	
Cost per ton.			\$5.94
38 man—hrs. per acre			
8 man—hrs. per ton			

TRACT III

EXPLOSIVES AND BLASTING SUPPLIES

311 lbs. Hercomite @ 25 cents.	\$77.75
510 No. 6 Blasting Caps @ \$16.15 per 1000.	8.24
1020 ft. Fuse @ \$8.91 per 1000 ft.	9.09

\$95.08

LABOR

Pitting 13.5 hrs. @ 28 cents and 2 hrs. @ 34 cents. . . .	4.46
Boring 67.5 hrs. @ 28 cents and 46 hrs. @ 34 cents. . .	34.54
Gas for Boring Machine—5 gals. @ 24.5 cents.	1.23
Blasting 75.5 hrs. @ 28 cents.	21.14
Grubbing 90 hrs. @ 28 cents and 74.5 hrs. @ 34 cents	50.53

\$111.90

Total cost for clearing five acres.

206.98

Cost per acre.

\$41.39

NUMBER OF STUMPS—WEIGHT LBS.

11th acre.	69	17975 lbs.
12th acre.	67	12835 lbs.
13th acre.	76	19065 lbs.
14th acre.	93	13495 lbs.
15th acre.	112	12350 lbs.

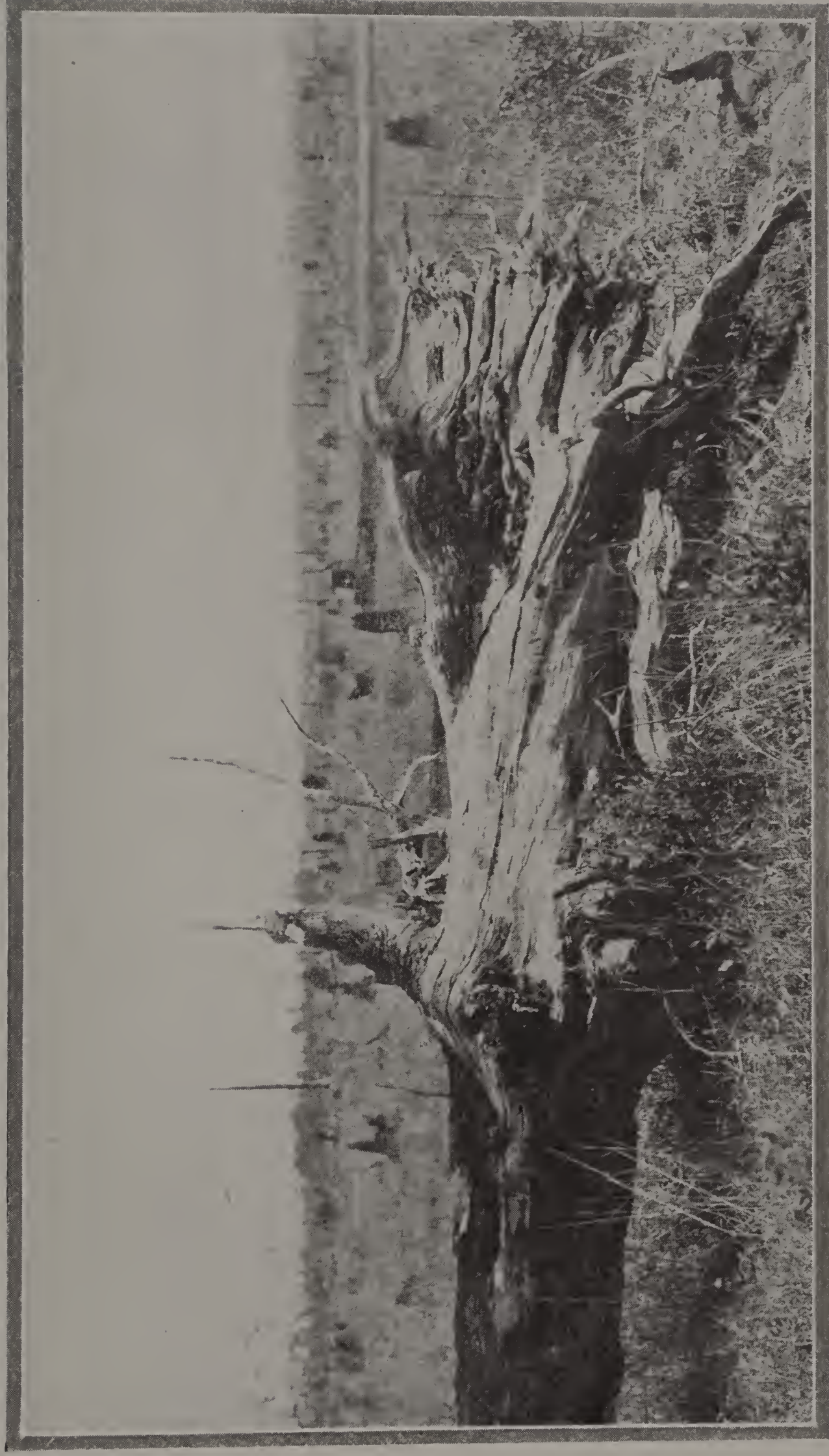
Total. 417 75720 lbs. — 37.86 tons

Cost per ton.

\$5.46

49 man—hrs. per acre

7 man—hrs. per ton



Long leaf pine stump removed mechanically. The tap root is larger than the part which was above ground and it is almost as much of a problem to dispose of this great weight of wood, once on the surface, as it was before it was pulled.

TRACT IV

EXPLOSIVES AND BLASTING SUPPLIES

187 lbs. Hercomite @ 25 cents.	\$46.75
285 No. 6 Blasting Caps @ \$16.15 per 1000.	4.60
570 ft. Fuse @ \$8.91 per 1000 ft.	5.08

\$56.43

LABOR

Pitting 6 hrs. @ 28 cents and 1 hr. @ 34 cents.	2.02
Boring 20 hrs. @ 28 cents and 20 hrs. @ 34 cents.	12.40
Gasoline for boring machine—5 gals. @ 24.5 cents.	1.23
Blasting 72 hrs. @ 28 cents.	20.16
Grubbing 66 hrs. @ 28 cents.	18.48

\$54.29

Total cost clearing 5 acres.

110.72

Cost per acre.

\$22.14

NUMBER OF STUMPS—WEIGHT LBS.

16th acre.	63	8670 lbs.
17th acre.	50	6620 lbs.
18th acre.	46	8715 lbs.
19th acre.	50	6505 lbs.
20th acre.	54	7140 lbs.

Total. 263 37650 lbs. — 18.83 tons

Cost per ton.

\$5.88

33 man—hrs. per acre

9 man—hrs. per ton

TRACT V

EXPLOSIVES AND BLASTING SUPPLIES

308 lbs. Hercomite @ 25 cents.	\$77.00
427 No. 6 Blasting Caps @ \$16.15 per 1000.	6.90
854 ft. Fuse @ \$8.91 per 1000 ft.	7.61

\$91.51

LABOR

Pitting 4.5 hrs. @ 28 cents and 4.5 hrs. @ 34 cents. . .	2.79
Boring 27.5 hrs. @ 28 cents and 33.5 hrs. @ 34 cents. .	19.09
Gasoline for boring machine—5 gals. @ 24.5 cents. . . .	1.23
Blasting 54 hrs. @ 28 cents.	15.12
Grubbing 91.5 hrs. @ 28 cents.	25.62

63.85

Total cost clearing 5 acres. 155.36

Cost per acre. \$31.07

NUMBER OF STUMPS—WEIGHT LBS.

21st acre. 60	9140 lbs.
22d acre. 30	6275 lbs.
23d acre. 79	5400 lbs.
24th acre. 60	8635 lbs.
25th acre. 107	8275 lbs.

Total. 336 37725 lbs. — 18.86 tons

Cost per ton. \$8.24

36 man—hrs. per acre

9 man—hrs. per ton

RECAPITULATION—LAND CLEARING

TRACT No.	COST	TONS RECOVERED	COST PER ACRE	COST PER TON
1.....	\$154.31	22.84	\$30.86	\$6.76
2.....	152.67	25.71	30.53	5.94
3.....	206.98	37.86	41.39	5.46
4.....	110.72	18.83	22.14	5.88
5.....	155.36	18.86	31.07	8.24
Total.....	\$780.04	124.10	Average. 31.20	6.28

MAN HOURS

No. 1	258	Man-hours	for 5 acres	—	52	Man-hours	for 1 acre
No. 2	190	"	" " 5 "	—	38	"	" " 1 "
No. 3	247	"	" " 5 "	—	49	"	" " 1 "
No. 4	164	"	" " 5 "	—	33	"	" " 1 "
No. 5	178	"	" " 5 "	—	36	"	" " 1 "

Total 1037

Average Man-hours per acre 41.48

No. 1	258	Man-hours	for 22.84 tons	—	11	Man-hours	for 1 ton
No. 2	190	"	" " 25.71 "	—	8	"	" " 1 "
No. 3	247	"	" " 37.86 "	—	7	"	" " 1 "
No. 4	164	"	" " 18.83 "	—	9	"	" " 1 "
No. 5	178	"	" " 18.86 "	—	9	"	" " 1 "

Total 1037

Average Man-hours per ton 8.35

CONCLUSIONS

The tables herewith shown give the clearing costs in detail.

Obviously, it cannot be assumed that \$31.20, the average cost per acre of clearing this 25-acre tract, is a close approximation of the cost of clearing all long leaf pine lands. The variation between the different five-acre tracts from \$22.14 per acre on Tract No. 4 to \$41.39 per acre on Tract No. 3, is in itself a sufficient indication that the average figure cannot be applied generally. However, it will be noted that the cost per ton of wood recovered was lowest on the land costing \$41.39 an acre to clear. The wood tonnage was heaviest on this tract, and as will

be seen, such land might be more profitable to clear in connection with distillation than land costing less to clear and yielding less material.

Tract No. 5 makes the worst showing, because of the low percentage of fat wood in the stumps on this area. Many of these stumps ran large and they were probably frequently overloaded because of experience gained in shooting others of the same size which contained more fat wood, and which were heavier. If these conditions were met frequently, experience would enable the blaster materially to reduce the quantity of explosives with equally good results. We believe there are millions of acres of cut-over long leaf pine lands that can be cleared at a figure close to \$30, millions more that will run higher than this, and other millions that can be cleared for less.

Whereas in shooting hard wood stumps the character of the soil is a vital factor in the cost, the same thing does not apply generally to the long leaf pine variety, because the charge is thoroughly confined within the root. There are sections in Florida, however, and possibly in other states, where the tap root is much less developed than usual, and where the extreme lightness of the soil coupled with this fact makes it necessary to use high percentage dynamites and considerably increases the cost of clearing.

While it is well to bring out these points, they are much less important in the present connection than they would be in the case of ordinary clearing where no attempt is made to utilize the wood. No matter how much or how little it costs to clear, this cost can be offset to some degree if the stumps are fat and as a general thing all long leaf pine stumps become fat or rich after they have been cut a few years. We cannot say that there are no exceptions to this, but we are confident that the exceptions are rare.



A power boring machine used in land clearing—Hercules Gulfport
Experiment.

PART 2.

SELECTING THE TYPE AND CONSTRUCTING THE PLANT

THE PROCESS known as destructive distillation is the only one which can be carried out with relatively inexpensive equipment, and, therefore, there was no choice in the matter of its selection. This produces charcoal, tar, and a product generally known as mixed tar oils.

There are many types of apparatus in use for destructive distillation. The cheapest outfit consists of an ordinary pit kiln. This makes a good tar, but an unsalable charcoal when resinous wood is used. The yield of tar is less than can be secured from a closed retort, and as the kiln is well known in the Pine Belt, its non-use for land clearing purposes indicates that some other type would be more satisfactory.

There are two general types of retorts in use for destructive distillation, the vertical and the horizontal. There are various modifications of these, depending upon the method of introducing the wood, and removing the charcoal. The consensus of opinion among operators favors horizontal retorts. The vertical type requires a special container and hoisting apparatus to introduce the wood and remove the charcoal. This can be eliminated, saving considerable expense, with a small size horizontal retort such as we decided to use.

We selected the one-cord size, 4 ft. 9 inches in diameter by 9 ft. 3 inches long, which, experience has demonstrated, was slightly too small for the most economical handling. The advantage of a retort of approximately this size is that charging and discharging can be accomplished quickly by hand.

The retort was set in a brick, fire-heated furnace. At one end was a door of full diameter. This swung on hinges and fastened to the ring on the retort rim by means of wedges. An ordinary worm condenser of $5\frac{1}{3}$ turns, 5 ft. in diameter, with the top of the coil seven inches in diameter and the outlet three inches in diameter, was connected with the end of the retort opposite the door. It was contained in a cypress water tank and led to a receiving tank of the same material, $3\frac{1}{2}$ ft. in diameter by 4 ft. deep, which was set in the ground. The water supply for the condenser tank was secured first from a bored well and later from a dug well. A small force pump connected to a pumping jack was driven by a crude oil engine.

A goose-neck trap was placed in the delivery pipe leading from the condenser to the receiving tank to hold back the gas and deliver the distillate. A 3-inch pipe conveyed the uncondensed gases to the fire box of the furnace, and a pipe was led from this up through the roof in order that excess gas could be by-passed into the air. In the bottom of the retort near the door, was an opening with a pipe connection through which the heavy tar, which did not vaporize, ran in liquid form into the tar tank made of concrete.

To regulate the temperature, the retort was supplied with three gauges, one glass thermometer and one thermo-couple element of an electric pyrometer were placed side by side in the vapor pipe. One thermo-couple was placed in the top of the retort near the door.

The retort and furnace were housed in a rough wooden structure and a narrow gauge track ran from the wood-pile on one side across the platform of a Howe Standard Scale through the retort house in front of the furnace and out to the charcoal house on the other side. A flat-car with a platform 4 ft. by 6 ft. 6 inches was used to bring the wood into the retort and furnace, and sheet-iron cooling boxes for the charcoal were placed on two similar cars. An office building with a lean-to shed for an automobile, and a small dynamite magazine with sand-filled walls, were also constructed. The cost of equipment and construction was as follows:

Office	\$380.77
Water Supply	218.08
Magazine	98.77
Outbuildings	23.82
Charcoal House	78.36
Retort House	182.47
Retort & Furnace	1500.17
Drains	39.93
Track	188.90
Gauges	98.51
Cars	208.84
Scales	112.54
Oil Pump & Connections	28.65
Tanks	317.68
Tar Pipe	36.33
Gas Pipe	48.87
Condenser	405.44
Misc. Tools & Office Supplies	78.69
Total	\$4046.82

CONCLUSIONS

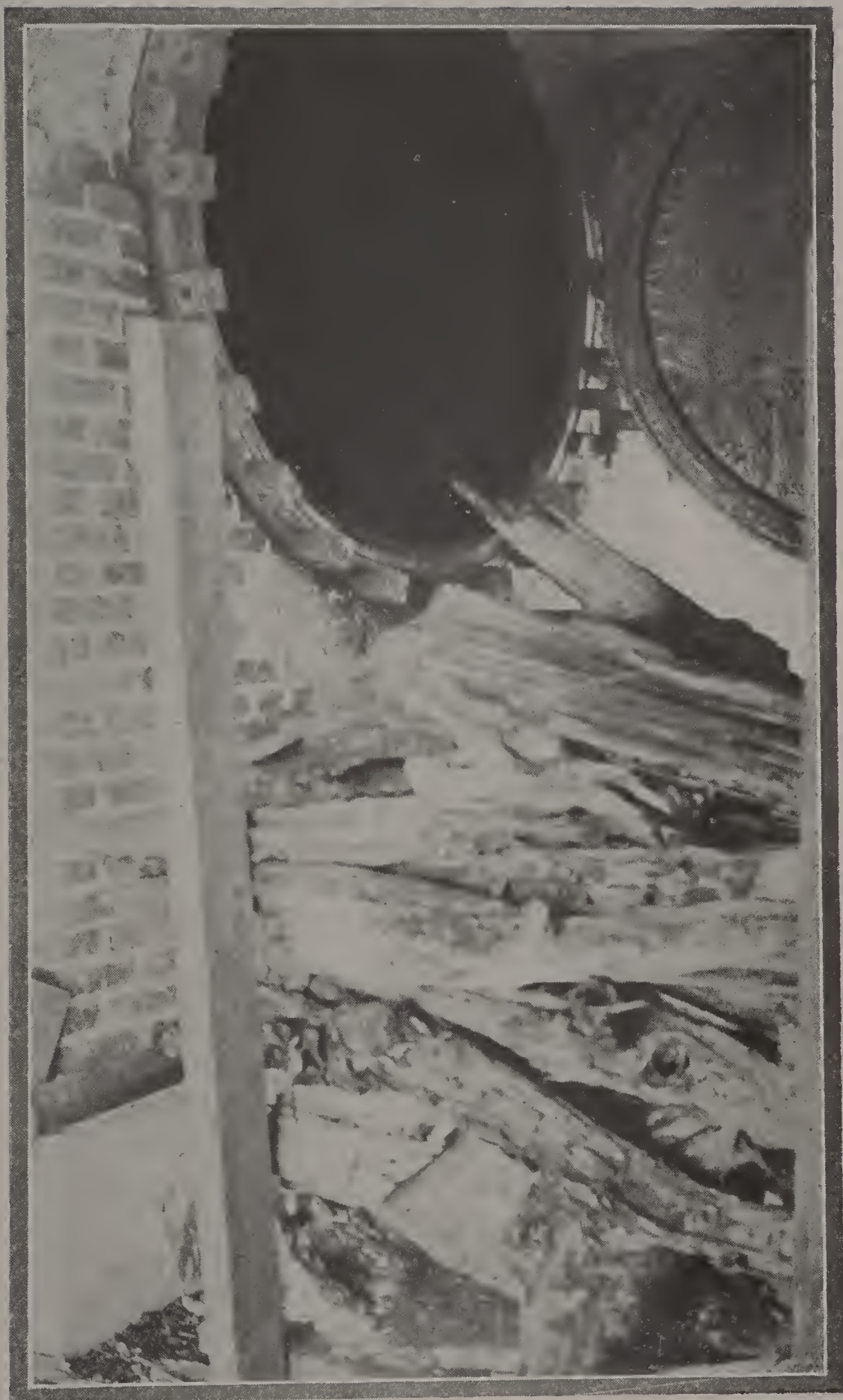
As the matter of accurate records was more important than any other factor in the case of our experiment, we went to some expense which would not be necessary in the instance of the average operator. It was built in the height of the war period when labor was even more scarce than it is today, and when it was extremely difficult to get prompt deliveries without paying a premium. The plant was located in an isolated spot where it was not possible to take advantage of any existing buildings. New equipment was used, whereas in many cases it is possible to make use of a second-hand boiler for a retort and other second-hand material. We believe it is possible to construct a plant with a slightly larger retort, using new equipment, for about \$3500.00, and this can be further reduced in cases where suitable second-hand material is available.

PART 3.

OPERATION

OUR METHOD of operation was as follows: Any wood that was not reduced to pieces eight inches through, or less, was split at the plant. The wood car was loaded and pushed on the scales for weighing. It was then pushed into the retort house and the wood was loaded into the retort in tiers. If any wood remained on the car this was re-weighed to get the exact weight of the charge. Wood which had also been accurately weighed was placed beside the furnace for fuel, the retort door was closed, and the fire started, the condenser tank having previously been filled with water, and the gas and tar pipes opened. The heating was rapid until the temperature became sufficient to cause the distillate to flow. The fireman was supplied with a sheet showing the temperatures which should be attained at half-hour intervals until the distillation was completed, and he was required to note the actual temperatures at these intervals on the same sheet. For a charge to be run off and pulled every twenty-four hours, it required an average increase in temperature of twenty degrees Fahrenheit each half-hour. At certain stages of the process, a rapid increase of temperature was expected, due to the heat produced by the breaking down of the molecular structure of the wood. Much gas was formed at this time. By observing the temperature readings frequently, warning of the approach of this action can be obtained. To avoid overheating, the fire must be pulled at this stage, and the gas by-passed to the air. With schedules of longer than twenty-four hours for the run, the heating is more gradual, and this sudden rise in temperature is not so pronounced.

During the first part of the run there is a flow of water and pyroligneous acid into the receiving tank. At the same time, tar collects on the bottom of the retort and runs off into the tar tank. Toward the middle of the run, the exact time depending upon the way the heating has been regulated, the tar oils are con-



This shows the open retort with the wood car alongside, ready for charging — Hercules Gulfport Experiment

densed and the uncondensed gases begin to flow into the fire box. In order to make a good quantity of charcoal, it is sometimes necessary to continue heating for a short time after the distillate ceases to flow.

In addition to the proper regulation of temperature, it is only necessary to see that the water in the condenser tank is kept cool, and that the pipe lines do not become stopped up and cause back pressure. We encountered no difficulties from this source, but if a serious stoppage occurs, it is necessary to draw the fire and pass the gas into the outside air.

When the distillation was complete the retort was allowed to cool until the reading of the pyrometer inside the retort showed a temperature of about 400 degrees Fahrenheit. The cooling box was then rolled into position in front of it, the lid on the top serving as a platform when open, on which the operator stood in raking out the charcoal. As the charcoal frequently catches fire, this operation has to be performed quickly. It usually took about ten minutes. After the charcoal was removed to the cooling box, the cover was closed and sealed with wet clay. From one to two days is required for cooling.

By the time the charcoal was sealed up, the retort usually cooled enough to permit a man to enter it, to clean out the vapor and tar pipes, and sweep the fine charcoal from the bottom. Another car of wood having been prepared, the retort was again charged, and the operation repeated. Each charge was handled in the same manner, except that the duration of the runs was varied in order to determine the length of time required to give the best results, and that in a few instances, the tar pipe was purposely stopped up so that the tar could be distilled through the condenser. However, this was found to decrease the yields.

TABLE No. 1
GULFPORT EXPERIMENT—24 HOUR SCHEDULE

OPERATING COSTS PER TON OF RETORT WOOD		
Hauling.	\$ 1.20	
Interest on Investment.	.65	
Depreciation.	1.33	
Retort Replacement.	1.00	
Repairs.	.50	
Supplies.	.60	
Labor.	6.45	
Total Operating Costs.		\$11.73
OPERATING REVENUE PER TON OF RETORT WOOD		
62.29 Gals. Mixed Oils and Tar @ 18 cents per gal.	\$11.21	
463 lbs. Charcoal @ 1 cent.	4.63	
Total Operating Revenue.		15.84
Operating Profit per ton of Retort Wood.		4.11
Operating Profit per acre		\$12.33

TABLE No. 1

In Table No. 1, the weight of the retort wood and fuel, and the yields of oils and charcoal, represent the average of a number of runs on the 24-hour schedule. The operating costs, yields, and profits have been worked out in terms of one ton of retort wood, or wood that is distilled, and the profits are also shown per acre.

Weighed at the time it was brought in, the wood recovered averaged five tons to the acre, but due to a slight loss in splitting, and to the evaporation of moisture, it amounted to 10% less than this, as it was actually used. Therefore, we can only count $4\frac{1}{2}$ tons to the acre. The wood required for fuel was almost exactly half of that which was used in the retort, by weight. This would allow us an average of three tons of retort wood and $1\frac{1}{2}$ tons of fuel wood per acre.

The wood we recovered averaged close to 1.5 tons to the cord, and theoretically we should have been able to put in this amount for each charge, but in practice we could not do so. As a matter of fact, our average on the 24-hour schedule was only 1.24 tons per charge. When heavier charges were tried, the large volumes of gases formed under the comparatively rapid heating required by the 24-hour schedule, were too difficult to control.

HAULING

It cost us 80 cents a ton to bring the wood into the plant, hiring teams when we could get them. As .5 tons of fuel were required for each ton of retort wood, the hauling cost per ton of the latter would be \$1.20.

INTEREST ON INVESTMENT

The interest on \$4,000.00 at 6% would be \$240.00 annually. As we distilled 1.24 tons of wood per day, in a working year of 300 days we would handle 372 tons of retort wood. Dividing this into the annual interest we get .645, the interest charge per ton.

DEPRECIATION

In figuring depreciation charges, it becomes necessary to estimate the time that the plant will be of use. Obviously, it would not give a fair picture to write off our plant in the short space of

time that we operated. As a land clearing proposition, we may assume, for bookkeeping purposes at least, that the plant will be useless to the owner by the time he has cleared his land, and the duration of this time will, of course, depend upon the amount of land to be cleared. We must arbitrarily establish the acreage to be cleared, and it seems to us that generally speaking a man would hardly employ the distillation process on less than 1,000 acres, even though, as can readily be seen, it might be possible to make a profit by using 500 acres, and doubling the depreciation figures. On a thousand acres, then, we can charge off our \$4,000-plant at \$4.00 per acre, and as there were three tons of retort wood to the acre, our depreciation charge per ton of retort wood, would be \$4.00 divided by 3, or \$1.33.

We remember that the plant consumes 372 tons of retort wood per year. As there are three tons of retort wood per acre, the other ton and a half per acre being used for fuel, the acreage handled per year would be 372 divided by 3, or 124 acres. At this rate it would take slightly over eight years to use the wood from a thousand acres. The original investment of \$4,000.00 would, therefore, be divided over this time, and the depreciation would be \$496.00 a year, or about 12%.

RETORT REPLACEMENT

In addition to depreciation, which should wipe out the original investment by the time the plant has served its purpose, something must be set aside to keep it in first-class running order during its life. The retort is the only thing likely to wear out rapidly. They have been known to last five years and over, and with careless firing they can be burned out in less than a year. Assuming that it will cost \$900.00 to purchase and install a new retort, if we charge \$1.00 per ton of retort wood, it will take 2.42 years to accumulate this amount, because we handle 372 tons per year, and this divided into \$900.00 gives this figure. With reasonable care, the retort should last at least 2.42 years.

REPAIRS

Before it is necessary to replace the retort, it will probably have to be patched and turned frequently, and we believe an allowance

of 50 cents per ton of retort wood should be made to take care of this and other small items of upkeep.

SUPPLIES

The figure of 60 cents per ton for supplies, is based on our own operations, and under this heading was included kerosene to run the engine, pump leathers, belt fasteners, flash light batteries, drinking cups, soap, cotton waste, and, in fact, all the small items that must be purchased.

LABOR

A plant the size of ours is a little more than two men can conveniently handle, and it does not provide enough work for three men. We were forced to employ three men, two at \$2.50 a day, and one at \$3.00 a day, two working in the day and one at night, making a total labor charge of \$8.00 for 24 hours. As we handled 1.24 tons of retort wood every 24 hours, the cost for labor per ton would be \$8.00 divided by 1.24, or \$6.45.

YIELDS

On the 24-hour schedule our average yield was 62.29 gallons of tar and oil, and 463 pounds of charcoal, for each ton of wood distilled.

PROFITS

We sold our oil in the summer of 1919 at 18 cents a gallon, which was a very low figure. We mixed our tar and oils, as is the usual practice, except on rare occasions when the price of tar goes high enough to make it profitable to sell it separately. Charcoal sells readily throughout the south at from $\frac{3}{4}$ cents to $1\frac{1}{2}$ cents a pound. We disposed of ours at 1 cent, which is an average figure.

TABLE No. 2

GULFPORT EXPERIMENT—36 HOUR SCHEDULE

OPERATING COSTS PER TON OF RETORT WOOD

Hauling.....	\$1.20
Interest on Investment.....	.83
Depreciation.....	1.33
Retort Replacement.....	1.00
Repairs.....	.50
Supplies.....	.60
Labor.....	8.13
Total Operating Costs.....	\$13.59

OPERATING REVENUE PER TON OF RETORT WOOD

76.40 Gals. Mixed Oils and Tar @ 18 cents per gal....	\$13.75
411 lbs. Charcoal @ 1 cent.....	4.11
Total Operating Revenue.....	17.86

Operating Profit per ton of Retort Wood.....	4.27
Operating Profit per acre.....	\$12.81

The analyses of the various headings in Table No. 1 will supply the method for arriving at those used in Table No. 2.

HAULING

Same as in Table No. 1.

INTEREST ON INVESTMENT

The interest per year would be the same, \$240.00, but as our average charge is 1.44 tons of retort wood in 36 hours, we only distilled two-thirds of this, or .96 tons per day, and 288 tons in a working year of 300 days. The interest per ton would, therefore, be \$240.00, divided by 288, or 83 cents.

DEPRECIATION

Depreciation would be the same as in Table No. 1, but as we only distill 288 tons a year, and as there are three tons of retort wood to the acre, we would take care of wood from 96 acres annually. At \$1.33 per ton, the depreciation per year would be \$383.04. It would thus take something over ten years to clear a thousand acres and accumulate a depreciation fund to wipe out

our original investment. In this case, the depreciation would amount to 9.6% annually.

RETORT REPLACEMENT

At \$1.00 per ton, or \$288.00 per year for retort replacement, something over three years would be required to accumulate \$900.00. The retort should last considerably longer with the slower schedule, because the rise in temperature is not so rapid, and, therefore, this longer time allowance for replacing it does not seem unreasonable.

REPAIRS

We believe the same estimate, 50 cents per ton of retort wood for patching and other repairs, is a conservative figure to use with a 36-hour schedule.

LABOR

In this case we divided our labor cost of \$8.00 for 24 hours by .96 tons, the amount of wood distilled in this period, to get the labor charge per ton of \$8.13.

YIELDS

Our average yield on the 36-hour schedule was 76.40 gallons of tar and oils, and 411 pounds of charcoal.

PROFITS

The selling price was the same, and as will be seen from a comparison of the two tables, the profits were greater, the increased yield of tar and oil more than offsetting the higher cost for labor and depreciation, and the decrease in charcoal yields.

CONCLUSIONS

From the foregoing analysis of our experimental operation, it seems impossible to escape the general conclusion that destructive distillation offers great possibilities for anyone who contemplates clearing long leaf pine lands on a fairly large scale. Experience proved that our retort was slightly too small. It should have been large enough to put in at least 1.5 tons of wood on the 24-hour schedule. We were forced to employ three men constantly, but where it is possible to employ one man for part time, the labor costs for a plant of this size can be slightly reduced. We sold our oil at a very low figure. At the present time it sells

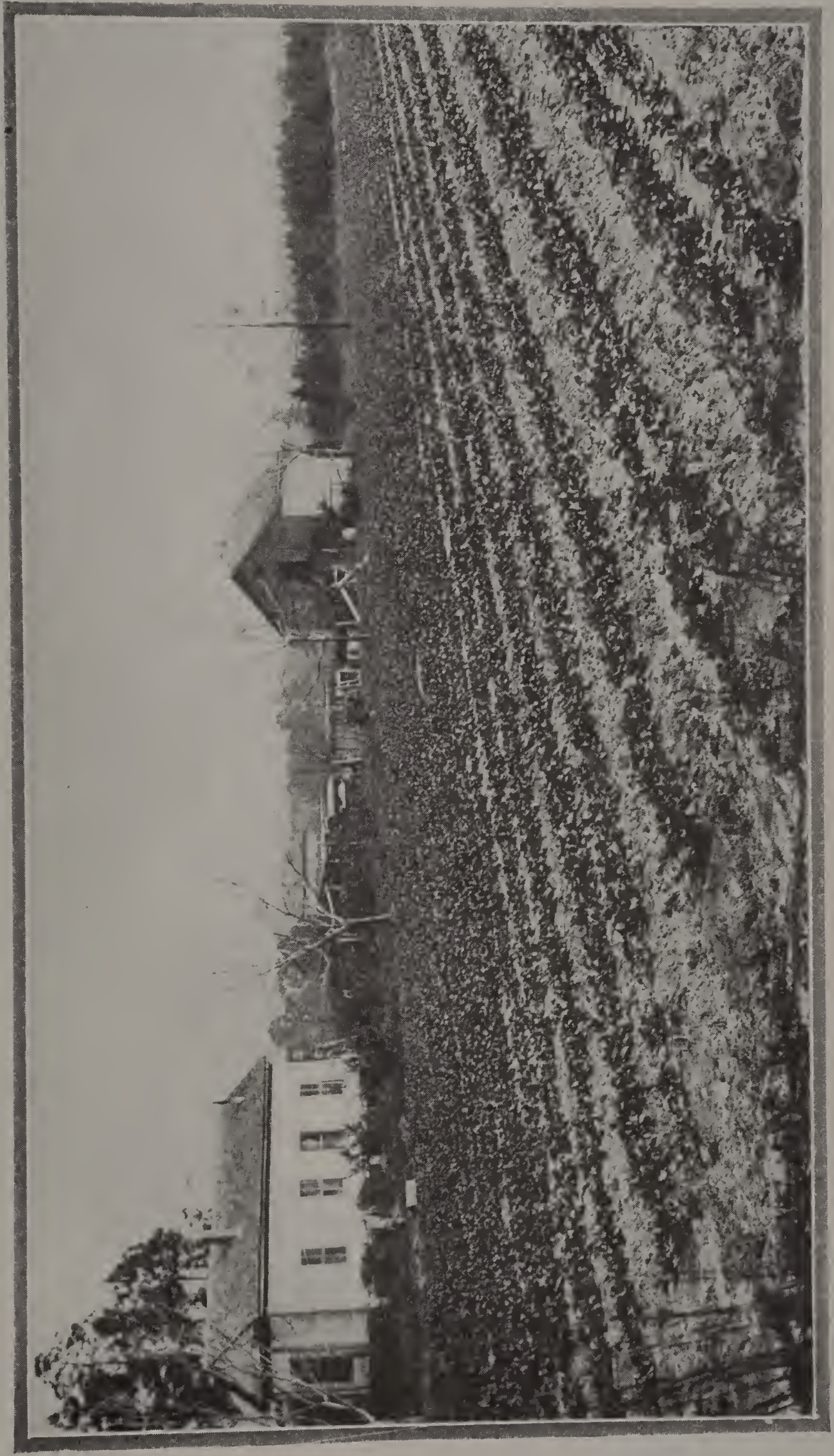
readily at around 30 cents per gallon, and brokers are offering 24 cents a gallon for the entire output of destructive distillation plants during 1923.

While the figure we got for our charcoal was fair, it was not by any means a top price. On the other hand our cost figures are very conservative. There will undoubtedly be considerable salvage value in the plant when 1,000 acres are cleared. We have made no charge for supervision because our supervision costs were all out of proportion to the enterprise. It is not necessary for the owner to devote more than one or two hours a day to supervision, except at the start and this time can be reduced when the operatives learn the work thoroughly.

There is a great deal of land which will yield more wood than that on which we operated, and the profits per acre will be considerably increased on such land. Particularly will this be the case where there is a large amount of down wood which can be gathered at little expense. There was practically no down wood on our land.

While our plant was probably the smallest size that can be profitably employed, larger plants can operate much more economically, and their use seems justifiable on any operation involving appreciably more than a thousand acres, possibly on this acreage. In Part 5, the extent to which the various factors mentioned influence final results is shown in detail with estimates of the profits it should be possible to secure under varying conditions with plants of various sizes.

While our operations show the 36-hour run to be slightly more profitable, it must be remembered that it takes longer to use the wood from a given acreage on this basis than on the 24-hour schedule. Also, it is possible that the difference between the two schedules may not be the same under all conditions, and individual operators should test this out for themselves before determining which length of run to use. We found that we got greater yields in thirty hours than in twenty-four, and more in forty-eight hours than in thirty-six hours, but the longest schedule decreased profits on account of the high labor cost.



A truck farm near Gulfport on land formerly covered with long leaf pine.

PART 4.

PRODUCTS: THEIR USES AND SALABILITY

MIXED tar oils produced by destructive distillation plants are sometimes referred to as commercial tar oils or, in the trade, merely as crude distillate. They contain a certain amount of turpentine which can be separated by re-distillation, but it would not pay to put in apparatus for this purpose in connection with the smaller destructive plants. The pyroligneous acid has no general commercial value, although it is quite possible that some of it might be sold locally as a disinfectant. It separates from the oils by gravity, and after a short settling period, it is pumped from the bottom of the receiving tank and is generally thrown away. As has been mentioned, the tar which melts out in liquid form is mixed with the oils, except on rare occasions, when it sells for a higher price than the mixed tar oils. The distillate is used in many industries, and, on account of the high prices which have prevailed in naval stores during the last six months, its use is steadily widening.

The following is quoted from a letter received from a naval stores broker:

“We may also state we are now buying the crude product such as you made at Gulfport (a mixture of distilled light oil and tar) at better than 30 cents per gallon f.o.b. distillery in tank car lots. There is every indication that this price will steadily increase, as the demand from the source we have in mind has more than doubled in this country in the past year, and the foreign markets have not been touched. One company we know of wants a tank car a day for the next twelve months. We are able to supply only one tank car a month.”

Mixed tar oils are used in the flotation process for separating ores in the mining industry, and in the manufacture of paints, disinfectants, such as cattle dips and insecticides, shoe polish,

paper, rope, insulation for electrical equipment, and for many other purposes.

The letter just quoted indicates pretty clearly that this material is readily salable at the present time, but, of course, it does not necessarily follow that this will always be the case. As in most any undertaking of a like nature, there are business chances involved. It is possible that enough plants will be built to flood the market, and cause prices to decline to a point where it is not possible to make a profit. However, our study of the situation makes us believe it is unlikely that such a condition can be created very soon.

The production of gum spirits of turpentine by tapping the trees is on the decline, owing to the diminishing supply of standing timber. In view of this, the prices of naval stores would naturally be expected to advance, or at least to hold firm at a level above that of the years when gum spirits production was at its height. Moreover, the demand for pine products from various industrial sources seems to be expanding. As compared to the output of gum spirits, the production of these plants is so small that it would take a very great number of them to have an appreciable effect on the market. These are the views which are current among naval stores operators and they seem to be based on the best available information.

The use of charcoal as a fuel is so well known throughout the South that comment on this product is unnecessary.

PART 5

ESTIMATES

TABLE No. 3

THE METHOD used in arriving at the various charges in Table 3, shown on page 26, is the same as in Tables 1 and 2. It will be noted that we are figuring on a retort that will actually hold 1.5 tons of wood. To do so, on a 24-hour schedule, it would have to be about 20% larger than the one we used.

The hauling charge is the same as in Tables 1 and 2. The interest on \$3,500 at 6% would be \$210.00 per year. As we handle 1.5 tons of retort wood per day, we would handle 450 tons in 300 working days. By dividing \$210.00 by 450, we get approximately \$.47 as the interest per ton of retort wood.

The depreciation would be \$3.50 per acre, if we write off the investment while distilling the wood from 1,000 acres. To get the depreciation per ton of retort wood, we divide the depreciation per acre by the number of tons of retort wood per acre, 3 in the first column, 4 in the second, and 6 in the third. It will be recalled that to get these quantities of retort wood per acre, the actual weight of wood would have to be 4.5, 6 and 9 tons per acre.

Plant replacement, repairs, and supplies, are the same as in the previous tables.

The labor charge is based on the figure used before, \$8 for 24 hours, but is divided by 1.5, the number of tons handled in 24 hours in this case, to get the cost per ton, \$5.33.

The profit per ton is secured by subtracting the costs from the revenue. To get the profit per acre, multiply the profit per ton by the tons of retort wood per acre, three, four, and six.

The time required to use the wood from 1,000 acres is obtained by dividing the acreage used per year (300 days x 1.5 tons, divided by the number of tons of retort wood per acre, 3-4-6) into 1,000. On the 36-hour schedule, one ton is substituted for 1.5 tons.

TABLE No. 3

ESTIMATED OPERATION ON 1,000 ACRES
ONE-RETORT PLANT — CAPACITY 1.5 TONS
COST \$3,500 — — — 24-HOUR RUN

FOR LAND YIELDING 3, 4 & 6 TONS RETORT WOOD PER ACRE.

OPERATING COSTS PER TON OF RETORT WOOD	3 Ton Land	4 Ton Land	6 Ton Land
Hauling.....	\$1.20	1.20	1.20
Interest on Investment.....	.47	.47	.47
Depreciation.....	1.17	.88	.58
Retort Replacement.....	1.00	1.00	1.00
Repairs.....	.50	.50	.50
Supplies.....	.60	.60	.60
Labor.....	5.33	5.33	5.33
Total Operating Costs. . .	\$10.27	\$9.98	\$9.68
OPERATING REVENUE PER TON OF RETORT WOOD			
62.29 Gals. Oil @ 18 cents			
463 lbs. Charcoal @ 1 cent. .	15.84	15.84	15.84
Oil @ 24 cents—Charcoal @ 1 cent.	19.58	19.58	19.58
Oil @ 30 cents—Charcoal @ 1 cent.	23.32	23.32	23.32
OPERATING PROFITS PER TON OF RETORT WOOD			
Oil @ 18 cents—Charcoal @ 1 cent.	5.57	5.86	6.16
Oil @ 24 cents—Charcoal @ 1 cent.	9.31	9.60	9.90
Oil @ 30 cents—Charcoal @ 1 cent.	13.05	13.34	13.64
OPERATING PROFIT PER ACRE			
Oil @ 18 cents—Charcoal @ 1 cent.	16.71	23.44	36.96
Oil @ 24 cents—Charcoal @ 1 cent.	27.93	38.40	59.40
Oil @ 30 cents—Charcoal @ 1 cent.	39.15	53.36	81.84
Approximate time required to use wood from 1,000 acres. . .	6.66 yrs.	8.88 yrs.	13.33 yrs.
Approximate time required to use wood from 1,000 acres run- ning on a 36-hour schedule. . .	10 yrs.	13.33 yrs.	20 yrs.

TABLE No. 4
ESTIMATED OPERATION ON 2,000 ACRES
TWO-RETORT PLANT — CAPACITY 3 TONS
COST \$6,000 — — — 36-HOUR RUN
LAND YIELDING 3, 4, & 6 TONS RETORT WOOD PER ACRE

OPERATING COSTS PER TON OF RETORT WOOD	3 Ton Land	4 Ton Land	6 Ton Land
Hauling.....	\$1.20	1.20	1.20
Interest on Investment.....	.60	.60	.60
Dépreciation.....	1.00	.75	.50
Retort Replacement.....	1.00	1.00	1.00
Repairs.....	.50	.50	.50
Supplies.....	.60	.60	.60
Labor.....	4.00	4.00	4.00
Total Operating Costs....	\$8.90	\$8.65	\$8.40
OPERATING REVENUE PER TON OF RETORT WOOD			
76.40 Gals. Oil @ 18 cents			
411 lbs Charcoal @ 1 cent..	17.86	17.86	17.86
Oil @ 24 cents—Charcoal @ 1 cent.....	22.45	22.45	22.45
Oil @ 30 cents—Charcoal @ 1 cent.....	27.03	27.03	27.03
OPERATING PROFIT PER TON OF RETORT WOOD			
Oil @ 18 cents—Charcoal @ 1 cent.....	8.96	9.21	9.46
Oil @ 24 cents—Charcoal @ 1 cent.....	13.55	13.80	14.05
Oil @ 30 cents—Charcoal @ 1 cent.....	18.13	18.38	18.63
OPERATING PROFITS PER ACRE			
Oil @ 18 cents—Charcoal @ 1 cent.....	26.88	36.84	56.76
Oil @ 24 cents—Charcoal @ 1 cent.....	40.65	55.20	84.30
Oil @ 30 cents—Charcoal @ 1 cent.....	54.39	73.52	111.78
Approximate time required to use wood from 2,000 acres....	10 yrs.	13.33 yrs.	20 yrs.
Approximate time required to use wood from 2,000 acres run- ning on a 24-hour schedule....	6.66 yrs.	8 yrs.	14.44yrs.

TABLE NO. 4

Table No. 4 (page 27) is worked out on the 36-hour schedule, so that, while the plant capacity is three tons, it would only distill two tons in 24 hours, or 600 tons in a 300-day year.

The depreciation divided over 2,000 acres would be \$3.00 per acre. The same labor required for a 1.5-ton plant, can run it. Keeping these facts in mind, the charges can be worked out as in the preceding case.

TABLE NO. 5

In Table No. 5 (page 29) 6 tons would be taken care of in 24 hours. The depreciation would be \$2.00 per acre. The labor is figured as three men at \$2.50 per day, and two men at \$3.00 per day, three working days and two working nights, a total of \$13.50 for 24 hours. This gives \$2.25 per ton of retort wood for labor.

The charge of \$1.00 per ton for retort replacement will replace all retorts at \$900 each, whether there be one or four, in two years on the 24-hour schedule, or in three years on the 36-hour schedule. The repair item allows \$225.00 per retort per year on the 24-hour basis, and \$150.00 per year with 36-hour runs. This should be an ample allowance.

TABLE No. 5

ESTIMATED OPERATION ON 5,000 ACRES
FOUR-RETORT PLANT — CAPACITY 6 TONS
COST \$10,000 — — — 24-HOUR RUN

LAND YIELDING 3, 4 & 6 TONS RETORT WOOD PER ACRE

OPERATING COSTS PER TON OF RETORT WOOD	3 Ton Land	4 Ton Land	6 Ton Land
Hauling.....	\$1.20	1.20	1.20
Interest on Investment.....	.34	.34	.34
Depreciation.....	.67	.50	.34
Retort Replacment.....	1.00	1.00	1.00
Repairs.....	.50	.50	.50
Supplies.....	.60	.60	.60
Labor.....	2.25	2.25	2.25
Total Operating Costs....	\$6.56	\$6.39	\$6.23
OPERATING REVENUE PER TON OF RETORT WOOD			
62.29 Gals. Oil @ 18 cents			
463 lbs. Charcoal @ 1 cent.	15.84	15.84	15.84
Oil @ 24 cents—Charcoal @ 1 cent.....	19.58	19.58	19.58
Oil @ 30 cents—Charcoal @ 1 cent.....	23.32	23.32	23.32
OPERATING PROFIT PER TON OF RETORT WOOD			
Oil @ 18 cents—Charcoal @ 1 cent.....	9.28	9.45	9.61
Oil @ 24 cents—Charcoal @ 1 cent.....	13.02	13.19	13.35
Oil @ 30 cents—Charcoal @ 1 cent.....	16.76	16.93	17.09
OPERATING PROFIT PER ACRE			
Oil @ 18 cents—Charcoal @ 1 cent.....	27.84	37.80	57.66
Oil @ 24 cents—Charcoal @ 1 cent.....	39.06	52.76	80.10
Oil @ 30 cents—Charcoal @ 1 cent.....	50.28	67.72	102.54
Approximate time required to use wood from 5,000 acres....	8.33 yrs.	11.11 yrs.	16.66 yrs.
Approximate time required to use wood from 5,000 acres run- ning on a 36-hour schedule....	12.50 yrs.	16.66 yrs.	25 yrs.

CONCLUSION

There is always some doubt as to the accuracy of estimates based on a small operation when carried into a larger one, but we believe that the possibility of meeting conditions varying widely from those we encountered is more apt to throw out these estimates than the fact that we have used our results in figuring on larger plants than the one we operated. In this particular case, enlarging the plant consists merely in multiplying the units with a consequent reduction of operating costs. There is no reason, therefore, why results should be affected by enlarging the operation in this way. As to differences due to conditions, there is no question that these will occur, but considering the fact that we took great pains to avoid the selection of ideal conditions, it would be most surprising if we had hit upon stumps that yield appreciably above the average. As a matter of fact, we know from the experience of other distillers that there was nothing phenomenal about the yields we secured.

We also know that the stumpage runs considerably heavier on a great deal of land than on that which we selected, and that there is frequently a large amount of down wood. Moreover, as will readily be seen, it would be possible to reduce both the yields and the weight of the wood shown in Tables 3, 4, and 5, and still have profits that would be decidedly worth while.

So far, we have been considering the application of distillation to land clearing solely from the standpoint of the landowner who may build and operate one or more plants. However, as distillation is a manufacturing business, there are probably a great many landowners who will not care to go into anything so foreign to their usual activities and, on the other hand, there are a great many who will welcome the opportunity to start a manufacturing business that offers a possibility for good returns and involves a comparatively small investment, but who would not care for the land development feature. A few such businesses have been conducted successfully for a great many years, but in most cases with plants larger than any of these we are considering.

It is clear, however, that under favorable circumstances, good profits are to be made on these small plants, even if a fair price is paid for the raw material. For instance, suppose we pay \$4.00 a ton for wood. This would make \$6.00 for each ton of retort wood, because half a ton is required for fuel. Adding this to the operating costs in Table No. 4, we should have \$14.90 under this heading. This would give us a profit per ton of \$2.96 with 18-cent oil, \$7.55 with 24-cent oil, and \$12.13 with 30-cent oil. The daily profits would be double these figures, as two tons are handled per day, and if we work 300 days a year, we should have annual profits of \$1,776.00, \$4,530.00, or \$7,278.00, according to the price of oil—fair returns on a \$6,000-investment. On the other hand, the landowner who can sell stump wood at \$4.00 per ton would receive from \$18.00 to \$36.00 an acre as an offset to his clearing costs. If we work out Table No. 5, handling six tons a day on a 24-hour schedule in the same way, we have annual profits of \$5,904.00, \$12,636.00, or \$19,368.00, according to the selling price of oil.

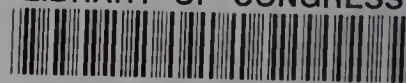
Of course, in working out a cost system for an operation of this kind, the charges would be arrived at a little differently, but they would hardly be more conservative than the figures we used on an acreage basis.

It is with some degree of hesitancy that we submit these figures, but, as we have explained fully the premises on which they are based we do not believe they can be misleading if considered in connection with this whole paper. Of course, in the case of a plant run purely as a manufacturing investment, if the owner devoted much of his time to it, there should be a considerable charge for supervision, although there would be no more necessity for his doing so than in the case of the landowner.

In conclusion, the Hercules Powder Company has no wish to force the impression that purely altruistic motives have prompted this work. Dr. Knapp and Mr. Evans have been good enough to say that we have made a valuable contribution towards the development of Southern agriculture. We are glad if this is true, and we shall be proud indeed if our sales work contributes towards building up our country agriculturally. We have gone into wood distillation as a matter of sales service. The information

and data we have obtained will be placed at the disposal of the United States Department of Agriculture and the public generally without obligation in any form, but, naturally, there is a great deal more to the erection and operation of distillation plants than can be set down in writing, and we have full confidence that we will be repaid in the sale of dynamite and blasting supplies by placing our knowledge on this subject at the disposal of those who contemplate land clearing, and co-operating with them towards making their work successful.

In closing, we cannot permit this occasion to pass without giving expressions of our appreciation to Mr. J. A. Evans, of the States Relations Service, who suggested this most interesting work to us, and to Dr. Knapp, Dr. Veitch, and others of the Department who gave us encouragement and extended to us many courtesies.



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